Weather Note

SOUNDING IN THE EYE OF HURRICANE ARLENE TO 108,760 FEET

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On August 9, 1963, at 1313 GMT, hurricane Arlene was located approximately 65 n. mi. southwest of Kindley Air Force Base, Bermuda, and was moving on a northeasterly course at 20 kt.

Approximately three hours later the passage of the eye at Kindley AFB was well documented by surface observations, CPS–9 radar, and a rawinsonde release in the eye. The highest wind speed measured at Kindley was 85 kt. which occurred prior to the passage of the eye. The relative calmness of the eye was first observed at Kindley at 1606 GMT, as can be noted from the wind recorder photograph in figure 1. A photograph of the radar scope, made at 1619 GMT (fig. 2), shows the detailed picture of the wall cloud. At 1616 GMT a radiosonde and rawinsonde transmitter was released in the eye of the hurricane; the sounding terminated at the record height of 108,760 ft. [1]. At release time the visibility was reduced to 1 mi. in fog (see table 1) and the ceiling was 1000 ft. obscured. Unusual brightness indicated that there were few clouds above the low-level obscuration.

This was the third time that a radiosonde release was made in the eye of a hurricane. Two radiosonde releases were made in hurricane eyes at Tampa, Fla. in 1944 (Riehl [5]) and 1946 (Simpson [6]). In 1962 a radiosonde release from Cape Hatteras, N.C., was carried into the hurricane aloft (Pope [3]).

Correlation between a plot of the balloon trajectory and CPS–9 radar pictures that were taken at intervals of 7 min. shows that the balloon remained in the eye of Arlene until it reached the stratospheric easterlies above 55,000 ft. It then moved to the west of the hurricane eye (see fig. 3). This indicates that the tropospheric portion of the 1600 GMT sounding is representative of the conditions in the eye of the storm.

TABLE 1.—*Selected surface observations, Kindley AFB, Bermuda, Aug. 9, 1963.*

Time (GMT)	Sky condition, visibility, weather	Pressure/temp./dew point	Wind direction and speed	Remarks
1455	W9X3/4 R+	999/76/73	←40+52	PRESFR
1555	Missing	M/M/M	←↖50+85	PRESFR
1606	W10X1F		←11	IN EYE OF ARLENE
1624	W10X1F		↘22+30	IN EYE OF ARLENE
1656	W10X1R+	M/77/74	↘50+67	LOWEST PRES 974.5 mb.

It is interesting to note the tropopause variations during the passage of the eye. There was a definite rise in the height of the tropopause over the eye of the hurricane, which is in agreement with Riehl's [4] model of a mature hurricane. As shown in figure 4, the tropopause over Kindley AFB generally increased in height until eye passage and then decreased. The tropopause was highest over the hurricane eye with a secondary high 12 hr. prior to the passage of the eye. The tropopause dis-

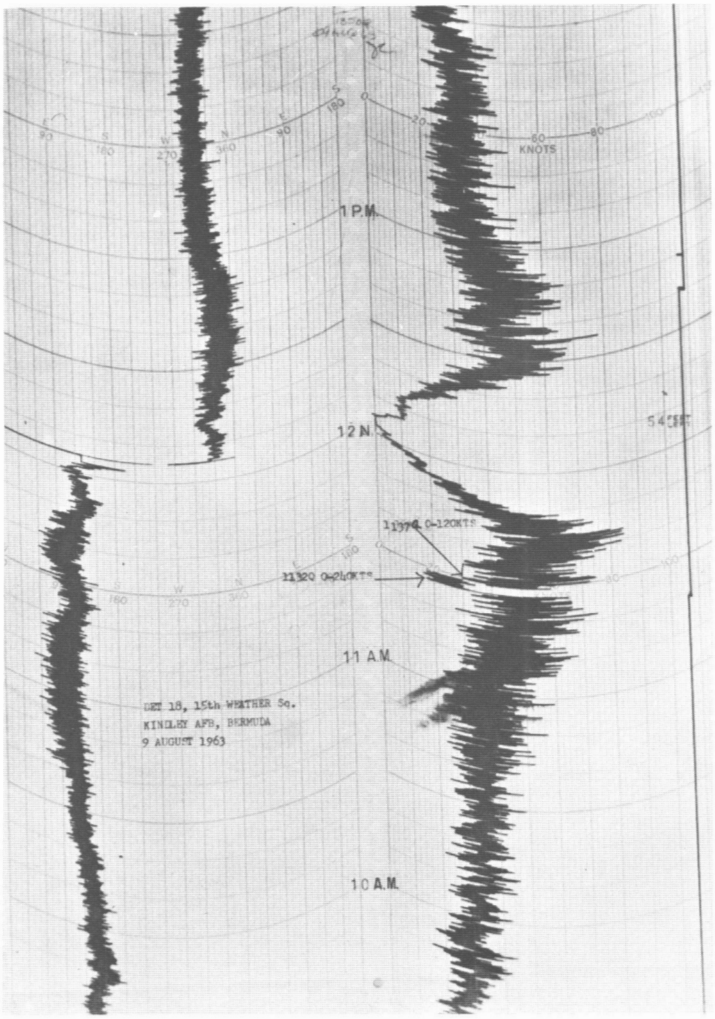

FIGURE 1.—Surface wind speed and direction as recorded at Kindley AFB, Bermuda, August 9, 1963.

cussed here is the conventional tropopause that has been internationally standardized by the WMO.

A comparison of the temperature in the eye with the temperature aloft at Kindley AFB when the storm was 90 mi. southwest shows that the temperature increased in the eye by 4° to 9° C. up to 150 mb. From 120 mb. to 90 mb. the temperature was slightly less in the eye (see fig. 5).

Jordan [2], summarizing data from numerous aircraft and dropsonde observations, has prepared mean hurricane soundings for three classes of hurricanes based on temperatures and humidities from the surface to 500 mb. Arlene, according to this classification, was an intense hurricane from 900 to 700 mb. and moderate from 700 to 500 mb. The relative humidity in the eye of Arlene, based upon one radiosonde and four dropsonde observations from 1200 to 2200 GMT August 9, are given in table 2. Compared to values presented by Jordan [2], Arlene's eye was much drier up to 700 mb. than would be expected.

The ascension rate of the rawinsonde balloon in the eye, compared to a mean ascension rate, gives evidence of the vertical motions in the eye of Arlene. Table 3 gives the ascension rates to 850 mb., 400 mb., and to balloon burst. Overall ascent is apparent from the surface to 850 mb. since the ascension rate was 14 m. min.$^{-1}$ greater in the eye than outside the eye. Up to 400 mb. there is evidence of subsidence, while to balloon burst there was overall ascent.

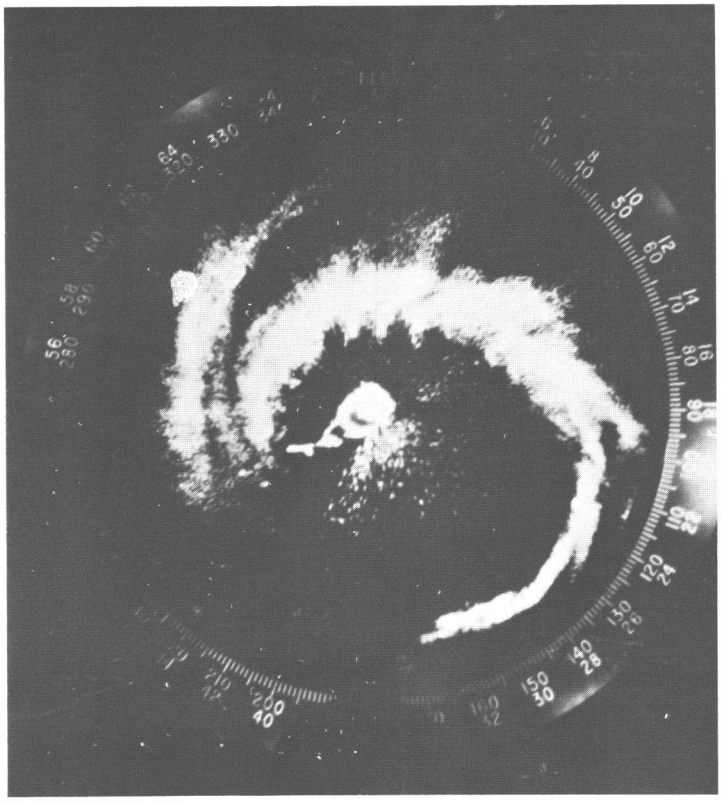

FIGURE 2.—Wall cloud of hurricane Arlene as detected by CPS–9 weather radar set. Range is 25 mi. Kindley AFB is at the center of the scope.

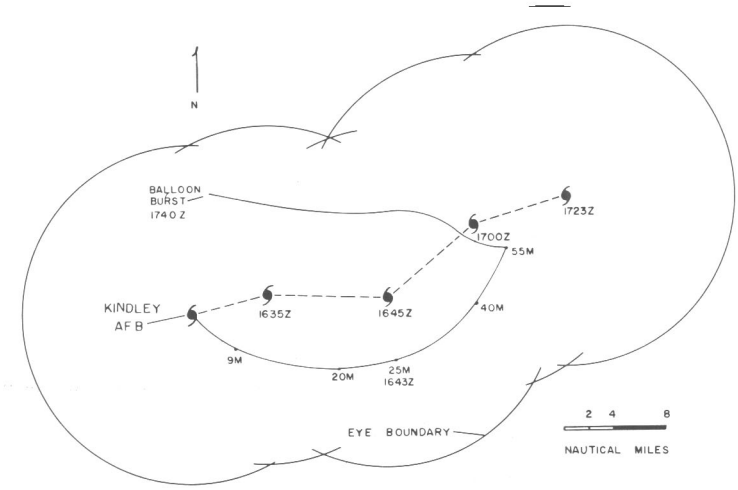

FIGURE 3.—Track of eye center of hurricane Arlene during rawinsonde run. Solid line is horizontal projection of balloon trajectory. Diameter of the eye at this time was 26 n. mi.

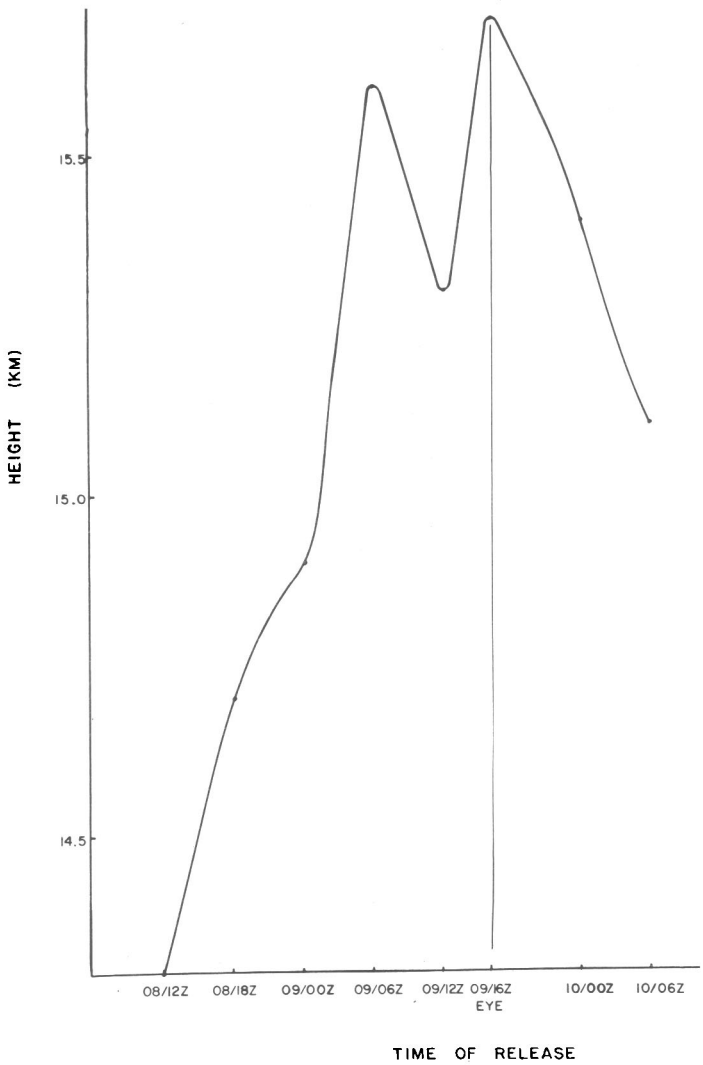

FIGURE 4.—Tropopause variations at Kindley AFB during passage of hurricane Arlene.

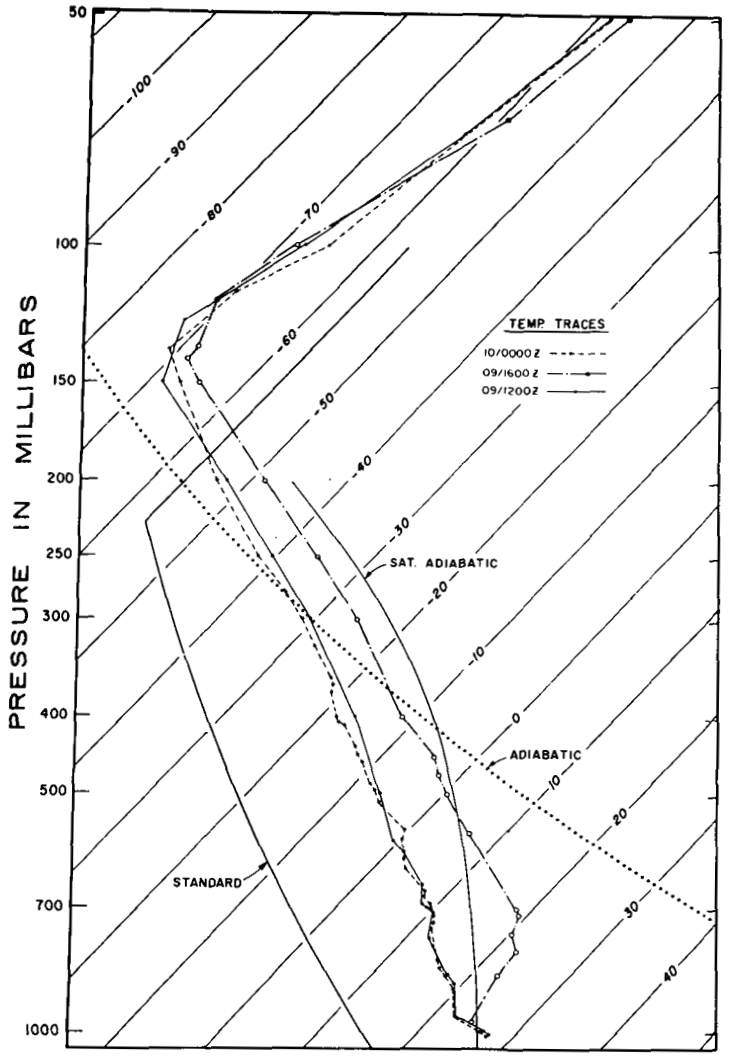

FIGURE 5.—Temperatures aloft over Kindley AFB before, during, and after eye passage. The trace labeled 09/1600Z is from the eye of Arlene.

Data were insufficient for any further calculations of ascension rates, but data available do support some of the present conceptions of a hurricane model.

TABLE 2.—*Relative humidities (percent) in eye of Arlene, Aug. 9, 1963.*

Level (mb.)	Time (GMT)					Mean
	1200	1300	1600	1900	2200	
950	100.0	76.5	85.0	81.0	M	86.0
900	92.0	87.5	86.0	88.5	M	88.5
850	61.5	89.0	86.0	73.0	58.5	74.0
800	47.0	85.0	79.0	56.0	56.0	65.0
750	52.5	72.5	70.0	60.0	60.5	63.0
700	51.5	51.0	62.5	64.0	62.5	58.0

TABLE 3.—*Ascension rates (m. min.$^{-1}$) of rawinsonde balloons.*

Level (mb.)	In eye of Arlene	Mean not in eye
850	287	273
400	277	290
Burst	370	347

In summary, the passage of the eye of hurricane Arlene over Kindley AFB Bermuda, on August 9, 1963, was well documented by surface observations, radar pictures, and a rawinsonde release, in the eye, that terminated at the record height of 108,760 ft. This was the third release ever made in the eye of a hurricane and the only sounding which reached such a high altitude. Correlation of radar pictures and the balloon trajectory show that all rawinsonde data were observed in the eye of the hurricane until it reached the stratospheric easterlies above 55,000 ft. The tropopause was highest over the hurricane eye. Temperatures in the eye aloft were 2° to 4° C. higher than those 90 mi. northeast of the eye. Relative humidities were lower than would be expected from studies by Jordan [2].

Surface observations at Kindley AFB indicate that Arlene was a weak to moderate hurricane at the time of passage, but compared to other hurricanes (Pope [3]), Arlene would be classified as intense in the lower levels. Ascension rates of the rawinsonde balloon in the eye of Arlene are worthy of note. Ascension rates of balloons from future releases in hurricane eyes might be a source of valuable information for futher research into the structure of the hurricane eye.

REFERENCES

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2. C. L. Jordan, "Mean Soundings for the Hurricane Eye," *National Hurricane Research Project Report* No. 13, U.S. Weather Bureau, 1957, 10 pp.
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4. H. Riehl, *Tropical Meteorology*, McGraw-Hill Book Co., Inc., New York, 1954, pp. 316–320.
5. H. Riehl, "A Radiosonde Observation in the Eye of a Hurricane," *Quarterly Journal of the Royal Meteorological Society*, vol. 74, No. 320, Apr. 1948, pp. 194–196.
6. R. H. Simpson, "A Note on the Movement and Structure of the Florida Hurricane of October 1946," *Monthly Weather Review*, vol. 75, No. 4, Apr. 1947, pp. 53–58.

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